Teacher's Manual

ZOÖLOGY

DESCRIPTIVE AND PRACTICAL

BY

BUEL P. COLTON, A.M.

AUTHOR OF "PHYSIOLOGY, EXPERIMENTAL AND DESCRIPTIVE," "PHYSIOLOGY: ILLUSTRATED BY EXPERIMENT," "ELEMENTARY PHYSIOLOGY," "PRACTICAL ZOÖLOGY"; AND PROFESSOR OF NATURAL SCIENCE IN THE ILLINOIS STATE NORMAL UNIVERSITY

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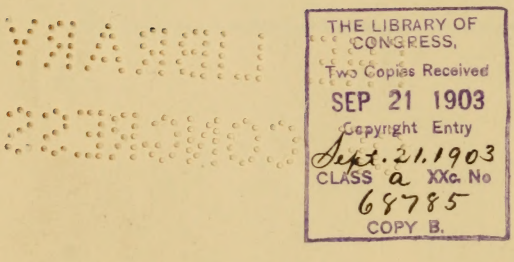
THE VOICE OF THE SEA

"The child holds a shell to his ear and hears the roaring of the sea. Do not yet tell him that the sound he hears is only the echo of the rushing of blood in his own head. In a higher sense the child is right. To him it speaks of the sea, its home. It brings the inland child a message from the vast ocean — the distant — the mysterious. It widens his narrow horizon; it takes him to the shore whose waters wash all other shores. He is no longer isolated, but put in touch with all the world. And this typifies the broad principle that one fact — considered in all its relations — involves the whole universe."



CONTENTS.

SUGGESTIONS TO THE TEACHER OF ZOÖLOGY.

EQUIPMENT AND CLASS-ROOM MANAGEMENT.

Tables. — In most schools it is necessary to economize in space as well as in the expense of equipment. The plan suggested will be to have two students at one table. This has some disadvantages, but economizes material, thus saving expense, and sometimes the teacher can get a specimen for each two, but not one apiece. Again, on some material two can work together to good advantage, one reading the directions while the other does the dissecting. By taking turns at the dissecting, each learns how to do the work, and sees about all there is to be seen. Such a table, for two, should be about twenty-nine inches high, four and a half feet long, and twenty-four inches wide. There should be at least two drawers, in which should be kept the tacks and pins in pattypans, or similar tin trays; a foot rule; a blowpipe with glass mouthpiece and nozzle connected by a foot of rubber tubing; the student's dissecting set, especially if he can carry a key to the drawer; scratch book, drawing pad, pencils, etc., as convenient.

Light. — The room should have mainly north light, and the tables should face the windows during the work of dissecting. If the teacher has a chance to plan the building, the windows should be ordered to extend *to the ceiling;* inside light is what is wanted, instead of architectural effect on the outside. Low windows do not let enough light into the back part of the room. If the room is on the top floor, a skylight is often desirable for lighting the back part of the room.

Ventilation. — A room used for dissecting, or any practical work in zoölogy, should be unusually well ventilated, because with a whole class at work, even if the material is fresh, the odor given off may be considerable. If the room has only ordinary means of ventilation, the teacher must look to the matter with care.

Water Supply. — It is seldom that there is an over-supply. In a large room a sink, with hot and cold water, in each corner of the room is none too much. With large classes there should be every convenience for the economy of time. Let each student have a certain sink to which he is to go, so there will be no confusion in passing. If the work must be done in a room where there is no water supply, a good-sized tank, with faucet, may be used to supply water, and large waste pails, made of galvanized iron, may receive the waste; and for washing the hands at the close of the work, a shallow wooden trough, lined with zinc, and of suitable length, may be used. This should have a spout, with faucet, or plug, at one end, so it may easily be emptied into a pail.

Towels and Soap. — There should be a good supply of towels hung on rollers, at least one at each sink. Soap should be always at hand, in soap dishes that are easily kept clean, and may stand in the sink. There should also be kept at each sink at least two nailbrushes, the cheap, wooden-backed kind serving very well. Suppose there is a class of thirty, not an unusual number in many schools; if they all have to wash at the same sink, they must wait one for another. But if there are three or four sinks, and each student knows where he is to go, much time may be saved. The teacher can find by a few trials how much time is required for a class to "clean up," and the science teacher must be careful not to detain a class, and thus encroach on the time that belongs to other subjects. It is well to have several large sponges and scrubbing brushes. Occasionally scrub the sinks with "lye." Any such material as drops of blood should be carefully wiped up from table or floor before it has time to dry.

Paper. — There should be kept on hand a good supply of paper on which to lay any material that would soil the tables. Manila

paper, or the straw paper such as butchers use, serves well for this purpose. Large sheets of old wrapping paper may be saved for this work, or even old newspaper will do.

Metal-top Table. — In a convenient part of the room there should be a table with a metal top. The edge of the table should be raised about two inches, making a shallow sink. The metal may be zinc, or, better, if durability is considered rather than first cost, block tin. At one end of the table there should be a sink, with water supply, set just under the metal, so that the table, made very slightly sloping, will drain into the sink. On this table all wet or sloppy material should be placed, as fish, clams, dishes to be washed, jars of alcoholic specimens, etc. When it is soiled, a stream of water may be played over it by means of a rubber tube attached to the faucet.

Exhibition Table. — There should be a table devoted to the showing of any specimens that may be brought into the class from day to day. This should be placed near the entrance, so the students will have a chance to see the specimens, at least while they are passing into and out of the room. The students should be encouraged to bring in specimens, and each should be expected to contribute something at least once or twice during the term. The common name of the specimen should be printed on a slip of paper and laid beside it. It is well also to state the locality from which it came and give the name of the collector. This gives the student credit for his work. It is well to give some attention to the forms thus brought in from time to time, even if they are not in line with the work of the day, for it is likely that many of them cannot be preserved, and similar forms may not be accessible again during the term. Sometimes it is a good plan to have the student who secured the specimen tell what he can about it, or detail a student to read up on the subject and report to the class. If there is a good reference library, it may be well to have the whole class read up on the subject. But usually the regular line of work will give them enough to do, and it saves time, and makes the members of the class mutually helpful to have individual reports

as above suggested. Judicious praise will stimulate pupils to do their best on such occasions. At any rate, such casual specimens should be used to the best advantage, and to take a little time daily for such incidental subjects adds variety to the work. If such talks are given at the beginning of the hour, it may help to overcome a tendency toward tardiness on the part of some pupils.

Preservation of Material. — Very early in the term show the class how to preserve a bird skin, so that all birds brought in may be kept in this way. Do the same with all other forms whose skins may be kept, as mammals, snakes, some fishes, etc. If alcohol can be obtained, use it for the preservation of suitable material. Have all insects saved, and, unless they are to be added to individual collections, let them increase the school collection. Thus a school will soon possess the nucleus of a museum. Let each pupil contribute something to this school collection, giving him credit on the label. Consult the directions given under the study of birds; also read the works on taxidermy in the list of books given. Have the pupils do as much as possible of the work of collecting, arranging, and labeling the collection. Rivalry between different rooms or different neighboring schools, is not a low or unworthy motive to stimulate such work. In all this work the teacher must lead, yet seem to follow; while directing, he appears merely to coöperate. He must be thoroughly in sympathy with the work.

Cages. — Many animals are so shy or so rare that the pupil has little chance of seeing them in their homes. Such forms as the raccoon, opossum, muskrat, mink, etc., are caught by trappers and frequently may be obtained alive. The teacher should see to it that there is a supply of cages in which to keep such animals. A good cage is rather expensive, but the school should own a few such. Others may be made by the teacher and pupils, with wooden frames, and wire-netting walls. The woodwork exposed may need to be covered with netting, or zinc, or tin, if gnawers are to be caged. Such cages should be kept near, if not in, the schoolroom, so the children may watch the animals, feed them,

and learn as much as possible about them. Birds are more easily kept. Turtles, snakes, and frogs are spoken of elsewhere.

Aquariums. — A fairly good aquarium may be made as follows. It is to have a wooden bottom and ends, and glass sides. Get a piece of pine board fifteen inches long, a foot wide, and two inches thick; this for the bottom. For the ends take two pieces of pine board a foot square and one inch thick. Half an inch from the edges of the bottom and ends make grooves to hold the edges of the glass. These grooves should be at least a quarter of an inch deep and wide enough to take in loosely glass of double thickness. Fasten the end pieces to the bottom with screws, making the grooves match. Partly fill the grooves with putty or aquarium cement, and slide the glass sides into place. Then carefully fill all cracks around the glass with cement. Take two light strips of wood of the length of the aquarium; lay them along the top at the sides, covering the edge of the glass sides, and screw them to the ends. Then paint the inside of the bottom and ends with good white paint, and the outside wood with any desired color. Let the paint become thoroughly dry before using the aquarium. Before putting animals into it, keep water in it awhile to remove anything from the paint that might injure live animals.

While such an aquarium may serve very well for a while, it is likely to warp and leak after a time. It is better to buy a good aquarium with iron frame; though the cost of it may be from five to ten dollars, it will prove a good investment. For smaller aquariums use candy jars, battery jars, fish globes, etc. There should be a number of these, for, generally speaking, different kinds of animals should be kept separate. The bottoms of most of them should be covered with gravel or sand, and the animals feel more at home if there are caves and grottoes in which they may hide. An aquarium should usually have some aquatic plants to keep the water fresh. Some of these may be found in the streams near you; if not, you can get them from dealers in aquariums. They are usually kept in bird stores and often by florists. Sometimes snails are desirable to help keep the aquarium clean. Aim to

keep a "balance" between the animal and plant life in the aquarium. Avoid overfeeding fishes. See that the water is renewed, but this will not need to be done often if proper balance is maintained. Do not allow an aquarium to be overcrowded. It should be covered when a room is swept, to keep dust out. Examine the aquarium every day and remove any dead specimens. Experiment to learn what animals can well be kept together, and also what plants are best.

Drawings. — The suggestions on this subject to the student are made on the supposition that he has had little training and experience. If otherwise, the teacher may modify the directions to suit their needs. The teacher will do well to have the first drawings made of very simple subjects, and *give* very *explicit directions*. Further, he should have the preliminary drawings made in the class room (always from specimens) and go about watching to see how they proceed. After a few trials under close supervision they may perhaps be trusted to work more independently. Many who might learn to draw very well are allowed to work without help; getting poor results, and being reprimanded, they become discouraged and no longer try. Show each one carefully just where his trouble is; encourage every good effort, even if it is far below standard. See that the student gets a good, square view, and in good light; otherwise you cannot expect good results. When a side view is represented, let it be the left side. When a student makes a drawing of a fish, see that he does not put in a human eye or a human mouth. The preconceived ideas are likely to ruin drawings, especially of such forms as are often seen in conventionalized drawings. Make him draw what he sees, and nothing else.

Notes. — Directions have been given the student on this subject. In addition the teacher may assign special subjects. It is interesting to detail one student to make special study of a specimen that he, or any one, may have found or brought in. Have him make a study of the thing itself, and read up on it in the best references at hand; then write a short account and read it to the class. In this way they will maintain their interest and greatly help each other.

Such division of labor enables the class to get much more than they otherwise could. It is a good plan to have some, if not all, of the class read some good book, such as Darwin on Earthworms, or Huxley on the Crayfish, and write a brief review of the book. For your own convenience have each student put his name and the date on each paper. You may find it convenient also, especially if you have several classes in the same subject, to have each student indicate the hour of his class and his seat. For example, if you have three classes, and the room is divided into two parts by a north and south aisle, and there are five rows of seats, the mark 1–E–1 would show that the student belongs to the first hour class, sits on the east side, and in the front row. This plan has been found very convenient in collecting, marking, and distributing the notebooks. By having these items placed on the margin between the perforations, with any marks you may make in correction, they are kept out of sight when the leaves are bound together.

Oral Presentation by Students. — In addition to having students make individual written reports of their study of specimens, it is a very helpful thing to have them make oral reports to the class. Instead of having one read a paper, let him merely give a talk; this, of course, should be carefully thought over (as all extemporaneous speeches should be). Have the student stand, facing the class across the exhibition table, as the teacher should do. Then, taking his specimen in hand, let him call attention to the more striking or interesting features, and explain how they are useful, whether it be a point of structure, the color, or whatever it may be. This gives him excellent practice in oral presentation, which he is not likely to have otherwise. Many students who recite very well when standing at their desks, would fail, on account of embarrassment, if called to the front of the room and made to face the class. But when he has an interesting specimen, which he has studied with some care and about which he feels that he is telling something new to his classmates, and especially as his hands have something to do, he is less likely to be conscious of the

fact that he stands facing the class, and he does not think of his timidity. This is a kind of training that most students very much need. Many persons, after leaving school, hesitate to face an audience; they know they have something to say, but are afraid to say it. Or, if they attempt to speak, their confusion greatly hinders them. The trouble with the old-style declamation was that the student had no thought of his own to utter. He was conscious that he was playing a part. And the majority of students shrink from such exercises, and, probably, when forced to perform them, derive little benefit. But the practice of writing, or talking, about something real, something present, something interesting, and having something to occupy the hands and keep the mind from the consciousness of the situation, — all these points give a *motive*, which the artificial nature of the old formal essay or declamation could never supply. The teacher should not fail to utilize such a fine opportunity to develop the student's power in expression, and so cultivate the art that he may acquire not only ease, but skill in it.

Microscopic Work. — If the school has but one or a few microscopes, as is the case in the large majority of schools, the teacher will have to prepare most of the mounts and have the students pass and look at them. The danger, in this work, is that the student may not see the relation of the minute part that he sees, to the whole from which it is taken. To make clear, the teacher should make a simple sketch, showing the relation of part to whole, labeling so much as is necessary. Of course the teacher should not tell the student all he is to see, for he should see for himself. Still, as this takes so much time, and should show something clearly, the teacher must make all effort to have it effectual. Suppose the teacher is to show the microscopic structure of an earthworm, the spinal cord, or the intestine of a cat. Let him then exhibit at least three, or better, four, specimens: (1) the thing itself, or at least a part of it large enough to show clearly to the naked eye, the spinal cord in position, an earthworm, or a section of intestine an inch or so long; (2) a microscopic section (trans-

verse) held by a clamp on a retort stand, set up so the students can see it on the level of the eye, toward a window (they can thus all see it well, save the time of handling, and not soil it or run the risk of dropping and breaking it); (3) a cross section under a very low power of the microscope (say a two-inch objective) so they can see the whole cross section moderately magnified; (4) a section under a medium or high power objective. By this means they will have passed gradually from the thing as a whole to the part under special study; from the gross to the minute, from the macroscopic to the microscopic. If something similar to this is not done, it will too often turn out that the microscopic work amounts to almost nothing. The teacher must help the student at first, for until he can *interpret* what he sees under the microscope, it is to him a foreign language (and a dead one, too). Of course it is to be hoped that many of the students may learn how to manipulate the microscope for themselves. Still, it is easy to overdo this sort of work. In all elementary courses the student must first learn what is to be seen with the naked eye, and there is so much of this work to do that the use of the microscope should be left, in the main, to advanced students. If there are two microscopes, it will save time to mount two objects alike and have the class pass in two columns, each in its own circuit. This is especially desirable if the class is large, or when viewing such interesting objects as protozoans or the circulation of blood in a frog's web, where it is desirable that each student have as much time as possible at the instrument. To avoid confusion and save time have a regular system of passing.

Dissecting. — The teacher's set of dissecting instruments should be more complete than that of the student, including in addition to what is recommended for the student, extra forceps, perhaps one pair with curved tip, extra scissors, finer, and perhaps one pair with bent blades, and a medium-sized pair of bone forceps. The teacher must see that the student does not get the instruments designed for medical students; such instruments as the tenaculum, and chain with hooks, are not needed by either student or teacher.

Many of the sets offered for students are unfit, especially in containing only a weak pair of tweezers, instead of good forceps that will grip at the tip. Such a set as the author recommends is now put up by Bausch and Lomb Optical Co., of Rochester, N.Y., and designated as set No. 14,042. The teacher will need, of course, to make many dissections for demonstration of points too difficult for the student to work out for himself. Many of these dissections take considerable time, and, so far as possible, should be prepared the day before they are to be shown.

In supervising dissection by students, the teacher will probably need to give especial attention to the following points: (1) that the student cut mostly with the scissors rather than with the scalpel; (2) that when he uses the scalpel, he use the handle more than the blade; (3) that the left hand be kept in constant use with the forceps, holding and steadying the parts under examination; (4) that the forceps be held like a pen, and not like tongs; (5) that organs be not touched with sharp point unless direction is given for so doing; (6) that when an organ is to be pushed aside or lifted, this should be done with fingers, or forceps, or the handle of the scalpel; (7) that he *follow* all *directions* faithfully, for if he is allowed to do otherwise, he is almost sure to waste both time and dissecting material.

Dissecting Boards. — There should be a dissecting board for each student. It should be a foot wide and eighteen inches long, of inch pine, dressed. In use this should be covered with paper, which may need to be held in place by tacks. By renewing the paper as needed, the boards may be kept clean, and thus last for years. Smaller boards may be found convenient for some of the work, but the above will serve for rabbits and pigeons, which probably are as large as any specimens dissected.

Dissecting Pan. — Get granite-ware pans about a foot long. There should be no handles either at the ends or side, as these are likely to be in the way. The most convenient form that the writer has found is an elliptical pan, one foot long, known in the market as "oval pudding pan." This has a smooth, rounded

edge on which the hand or wrist may conveniently rest. For a bottom board on which to tack the specimen, when dissecting under water, get a piece of soft board, ten inches long, six inches wide, and three sixteenths of an inch thick. A piece of shingle may be used, but it is better to have it dressed at least on one side. For a weight to hold it down get a piece of copper trolley wire, one fourth of an inch thick and two feet long. Bend this into a ⊂-shape, which should be about ten inches long and five inches wide. These weights have the advantages of not rusting and not being easily broken, and their shape can be readily changed to suit convenience. For tacks get ordinary carpet tacks, the tinned ones preferred, as the others rust so readily; also the double-pointed tacks, such as are used in fastening down matting and oilcloth. In fastening such a form as the crayfish this kind of tack may be straddled over the slender bases of the big claws, and will hold the specimen, which would be a difficult thing to do with ordinary tacks. There should also be a supply of common pins for each student, for dissecting such small animals as the earthworm. After removing the tacks or pins they should be promptly and thoroughly dried to prevent rusting. To do this it is well to spread them out on paper, rolling them about to absorb the water. The board should be set on end to dry. The teacher must see that the student renews the water in his dissecting pan as often as it becomes turbid. The beginning student is likely to lift his specimen out of water, thinking to see it better, and he may not realize that he cannot see as well as before. See to it that he keeps the specimens under water unless for some needed manipulation. There should be a dissecting pan, with complete equipment, for each student.

If the student does much dissection of small specimens, it may be desirable to have a set of smaller dissecting pans, with boards and weights to match.

Laboratory Period. — It is best, when possible, to arrange the work so that there will be a double period for laboratory work. For instance, suppose the regular recitation period is forty-five

minutes. If, on the days when dissecting or other laboratory work occurs, two periods, that is, ninety minutes of continuous work, can be arranged, it will save time. It may be possible to have all laboratory work in the afternoon and get double time two or three days a week. In doing laboratory work in the ordinary recitation period there is often considerable loss of time. If a dissection is not completed, the material has to be put away and gotten out again the next day. By carefully planning the work the teacher may save both time and material.

Preserving Specimens during Dissection. — When a student has to lay aside a specimen before finishing a dissection, two plans may be followed. First, provide each student with a wide-mouthed jar containing a preservative. This is probably best for small specimens. When using larger specimens a large earthen jar or metal can or tank may be used. In this case each student should label his specimen with a metal tag on which his name is written or scratched. Of course the jars should be kept tightly covered. But if the school has no alcohol or formalin, and a good supply of material can be secured, the class can get along very well. In the dissection of the crayfish, for instance, if the circulatory and digestive system be studied the first day, another specimen may be used the next day for the muscles and nervous system. This plan is suggested for schools where there are plenty of boys to gather specimens, but limited funds for buying formalin or alcohol.

How to dispose of Refuse. — After dissecting under water there remains the water with more or less of small scraps of tissues. If this is emptied into a waste pail, it makes a heavy weight to lift; if emptied into a sink, the scraps are likely to clog the pipes. The following method of separating the scraps from the water is recommended. Make a strainer by nailing wire screen, of quarter-inch or half-inch mesh, over the bottom of a shallow box after removing both top and bottom. This should be set on a support in a sink, so the water can run freely through it. Lay over this strainer a piece of mosquito netting. When the students are done dissecting, have them first remove the tacks or pins; when they pass to

the sink, they are to lift out the board and weight ; then empty the water into the strainer ; after this the netting, with the scraps, may easily be transferred to the waste pail. Each student should then thoroughly rinse the pan, board, and weight, and leave them in the sink, if they are to be used soon by another class, or put away where they are regularly kept. When a whole class is to pass at one time to empty their dissecting pans, they must be cautioned to hold the pan firmly, to walk slowly and carefully ; otherwise they are likely to spill the water on the floor or on each other's clothing, especially as they crowd up around the sink. Each one should be cautioned not to come up close to the one in front of him, nor to make any sudden backward movement. There should be a regular system of passing so they will not interfere with each other.

After dissection on paper the soiled paper and refuse may be dumped into the waste pail. Before starting from his table the student should carefully wrap the paper in *from all sides* around the remains ; if he simply folds the two opposite edges of the paper together, as he is apt to do unless specially instructed, when he is carrying the paper, scraps are likely to fall out at either end. The worst of it is these scraps are often unnoticed and are tramped on, especially in the haste of dismissal at the end of the laboratory period, and the material is carried along, staining the floors of other rooms as well as the room where the dissecting was done. The material, left from dissecting without water, is best disposed of by burning.

Getting Alcohol. — Alcohol for school use may be obtained by the barrel without paying the internal revenue tax. Write to the internal revenue collector of your district for instructions as to the form of procedure. After complying with the prescribed conditions, the alcohol should be ordered from the nearest distillery.

Formalin. — Formalin is an excellent preservative and is much cheaper than alcohol. Dilute one pound of formol in twelve quarts of water. This makes a good solution for general laboratory use, being about four per cent. For some purposes a weaker solution will be sufficient. In using either alcohol or formalin there should

be at least twice as much bulk of liquid as of material to be preserved. But, of course, after a time the preserved material becomes saturated, and then it may be kept in a smaller quantity of the liquid. It is desirable, in shipping, to use as little liquid as possible.

Laboratory Supplies and Apparatus. — Of course all laboratory supplies, apparatus, microscopes, etc., should be furnished by the school. But the teacher who introduces practical work into a school where such work has not been done may find various hindrances. In the first place, there will be little provision for such work, sometimes absolutely no equipment. In the second place, the school board may not see the necessity of spending money for such an outfit as the teacher may desire. In such cases it may pay the teacher to go ahead and get some things at his own expense. If, later, he can show the board that these things have been wholly devoted to school use, and that they have been the means of teaching lessons that otherwise could not have been learned, and that it is *worth while*, then such a board is usually ready to say, "Yes, certainly, the school ought to pay for these things, and not expect the teacher to take from his meager salary to supply a school district that is well able to buy what its children need." Especially are such men likely to be ready and willing to use school funds for such purposes if they find that their own children have learned something valuable, and are becoming more interested in school work than they were before. The average business man judges by *results*, and the wise teacher will sometimes wait to show results instead of asking in advance for what seems to be a mere fad. In school, as in business, men will invest in what *pays*. The writer knows this to be true from his own experience, even to the extent of buying a fairly expensive microscope.

COLLECTION AND PRESERVATION OF MATERIAL.

Excursions. — The only way to get acquainted with Nature is to visit her. "If you study Nature indoors, when you go outdoors you cannot find her." The teacher must go afield, and take his

students with him. It is well, before taking a whole class, for the teacher to go over the ground alone, to "spy out the land." But the teacher must not hesitate to take the children because he does not know all about all he sees; if he waits for this, he will never go. To know animals one must see them in their homes. On as many Saturdays or afternoons as possible take the entire class with you, and show them how to collect specimens. But when you wish to collect material for class use, it is better to take a few of the "big boys" who are interested in outings. They may soon be trained to be valuable assistants, both in the field and in the class room. To spend the day thus with enthusiastic boys is ideal teaching, and the writer recalls with pleasure many days thus spent; he cherishes the hope that some of his students also look back upon them with pleasant memories. Often more may be learned during a day in the field than in a week of laboratory and library work. And the great point about it is that what is so learned is remembered, while what has been merely read has completely escaped the memory.

Collecting Outfit. — As early as possible the teacher should see to it that he has the necessary equipment for collecting. Among the things he needs are a minnow seine twenty or twenty-five feet long, three or four feet deep, with one fourth inch mesh, with sinkers and floats; seines are not expensive and can be obtained of dealers in fishing tackle. Care must be exercised not to tear the seine on snags; when it gets caught, stop and loosen it, as effort to drag it loose often tears the net. After using the seine, dry it thoroughly before putting it away, or it will soon rot. Fork handles may be used as handles; but it is often more convenient to carry it without handles, as temporary handles can usually be made along the shore where seining. It is hard to drag such a small-meshed seine against a current; unless there are strong persons to handle it, it is better to drag down, or across stream, or especially in still bays, where it is easy to corner many specimens. Care should be taken, in dragging the net, to "keep the lead line down"; otherwise many fine specimens may escape

under the bottom of the net. Select a smooth, clean landing place. A third person should follow with a minnow pail, in which not too many specimens should be placed. Give plenty of fresh water, and, so far as possible, keep the minnow pail standing in water near the bank, but be careful that it is not washed away. If it has means of fastening, use it, so if the pail is accidentally upset, the specimens will not be lost. Do not set the pail in the hot sunshine. Renew the water on the way home if needed. Wading boots are necessary, but in warm weather old clothes and old shoes to protect the feet may be used. The mackintosh wading pants are excellent for the seiner who carries the far end of the seine. There should also be a supply of fish baskets (for collecting birds), shell bags, boxes and bags for specimens. Find out what boys in the class have guns, and enlist their services in securing birds and mammals. But be sure to instruct them as to what birds to shoot and when, and how to care for the specimens. Do not allow needless shooting, none in breeding season, none of the home or song birds, and as few as possible of the useful ones. Crows, jays, crow blackbirds, and most of all, the English sparrow, are suitable for class work. In short, have the best equipment possible, and enlist the whole class in the work of collecting. In the field work they will often learn more than in the class room. Each Monday, at least, should see a number of new specimens on the exhibition table. In the warmer weather have the material kept in a cool place till used.

Reserve Material. — Plan all your work well ahead. Have on hand a good supply of material so you will not have to resort to book work ahead of practical work. If you have nothing in reserve, you may often lose valuable time. For instance, suppose you plan to get clams or birds on a given Saturday. You may be disappointed, the water may be too high to get the clams, or they may be scarce where formerly you have found them abundant; "there's many a slip." Get clams, crayfishes, and such forms that can easily be kept alive, some time before you expect to use them. Turtles, frogs, clams, crayfishes, earthworms, snails, pro-

tozoans, and perhaps some other forms may be obtained early and kept on hand; alcoholic specimens should of course be secured early as they keep indefinitely. Insects may be obtained early, though it is best to study them when they are most active, and as the student should do most of the collecting of insects, it is better to study these as they are collected. Birds cannot well be kept, but must be studied as fresh as possible. The order is not of very great importance, and the teacher must be ready to change his plans to suit the existing conditions. For instance, if a class has become interested in outdoor work, the teacher may, any morning, find in his class room a fine lot of material that a student has brought in. Often it is desirable to study this at once. Of course it may be inconvenient to change one's plans suddenly, but unless the teacher can do this, valuable material often fails to be used to the best advantage.

INSECTS.

Collecting Insects. — Collecting insects is comparatively easy, and as it is so well suited for the work of the students, directions have been given in the suggestions "To the Student." The teacher should aid the student by setting the example, for such matters are learned better by example than by precept. The teacher should provide himself with the best available directions for collecting and preserving insects, such as "Directions for Collecting and Preserving Insects," Riley (Bulletin of the United States National Museum, 25 cts.).

While the students should collect insects for themselves, it often happens that when you wish a uniform lesson, they have not all the same kind. The teacher will do well, therefore, to secure a good supply of specimens to use when needed. Often in September or October the monarch butterfly may be found in flocks. If they are found in numbers during the day, watch them, or detail a student to do this, and find where they settle for the night. On a frosty or cold morning they may sometimes be caught by hundreds. For this a long-handled, large-mouthed net is desirable. Sometimes they "roost high," and it may be necessary to use long

ladders. On one occasion the writer found them at the outer end of a high limb. How to get them was the question. The problem was solved by getting a long ladder, guying it by ropes held by three or four strong young men, while one climbed the ladder and scooped them in. They may be killed by chloroform, and if not to be used at once, should be folded in papers as directed for students. A good supply of bugs, beetles, grasshoppers, bees, and flies should be made. Most of these are best kept in alcohol. A whole hornets' nest may be captured by slipping a net over it. This is more convenient if the nest is near the end of a branch, so the net will not be torn before it incloses the nest. The writer has thus captured an entire hornets' nest, and taken them home alive. Then by making a small hole in a corner of the net they may be let out, one at a time, under tumblers on a plate or piece of glass, and each student, or each two, may have a live specimen to study. By introducing a drop of honey or sirup the method of feeding may be learned. A nest may also be captured by quickly plugging the entrance and then injecting chloroform till they are killed. Most boys know how to capture bumblebees in a jug.

STUDY OF A HIVE OF BEES.

Time of the Year to study Bees. — The best time of the year to make a study of the honeybee is in the spring. Begin the work during the fruit-blooming period, and continue it to the end of the school year. The work may be done later in the year, commencing with the opening of school in September; but an early frost or an exceptionally dry season would produce conditions unfavorable to the best work. In either case, the bees would probably have difficulty in securing nectar and pollen, and brood rearing would be greatly restricted or cease entirely. Under these conditions the study could not be otherwise than unsatisfactory. The writer has had classes pursue this study during each of the seasons mentioned, and though those studying during the latter period met with a fair degree of success, it was by no means equal to that attained by those making the study earlier in the year.

Placing of Bees in the Observatory Hive. — An observatory hive is essential in the class-room study of the honeybee. This hive is narrow, being wide enough for one or two brood frames, as may be desired, and is provided with glass sides. Any one handy with tools can make one in size to correspond to the size of the brood frame to be used. The A. I. Root Co., at Medina, Ohio, sell an observatory hive for one Langstroth frame. Inquiry of them will secure particulars concerning it. After making the observatory hive, or securing it ready made, as the case may be, the next step is to secure the bees and get them to working under as natural conditions as possible; and at the same time have them where observation may be made without the interruption of either the observer or the observed. If the teacher or some pupil has had experience in handling bees, few directions are needed; but if they are without such experience, the services of some bee keeper should be secured.

Select a brood comb containing brood in the different stages of development. There should be some honey in the cells along the top bar, and pollen or "bee bread" in some of the cells near the brood. Place this comb, together with the bees which cling to it when it is removed from the parent hive, in the observatory hive. If the quantity of bees removed with the comb is not sufficient to cover the comb, more should be gently brushed from other combs upon this one after it is in place. There should be about a quart of bees on the comb in the observatory hive. Securely fasten the cover of the hive, having previously closed the entrance. Care should be taken to avoid suffocating the bees. Provide for ventilation, if there is no provision for it, by boring a few holes in the bottom, top, and ends of the hive and covering them with wire cloth. This should be done before the bees are placed in the hive. Before attempting to transport a hive of bees be sure that no bee can escape. This is for the safety of all concerned, and possibly of some that are not. The hive is now ready to be carried to the place where it is to be set up for observation. A shawl strap makes a convenient carrier. The handle should be placed

at the top of the hive. The contents are then in the natural position, and are little disturbed in transportation.

Placing the Hive at a Window. — Place a desk or table against the wall before a window; a north window is preferable if one is conveniently located, otherwise shade the hive from the direct rays of the sun. The top of the table should be level with the top of the window sill. A shelf on brackets will serve as well and may be preferable. Place upon the table the observatory hive with its contents. Push the entrance end of the hive up to the bottom rail of the lower sash. Raise this sash two inches, and push the entrance beneath it at as near the middle point as may be. Close the opening thus made on either side between the hive and the side of the window with strips of board of proper size. Be very sure that there is no opening by which bees may get into the room. Liberate the bees by opening the entrance.

If at any time bees escape into the room, they will probably fly to the glass above the hive, and may be put out of doors by lowering the upper sash and gently brushing them upward to the opening.

If the teacher has followed these directions, he now has a hive of bees in a position where the bees are working under natural conditions, and where the home life of the bees may be studied by looking through the glass sides of the hive. If the light from the sides upon the bees and comb is not as good as desired, a mirror may be used to direct it. In this way light may be thrown to the bottom of the cells. When not open for observation, the sides of the hive should be kept closed or darkened, that the interior of the hive may be dark, and the conditions there in this respect be the same as in a hollow tree, the natural home of the honey bee.

CRAYFISHES.

How to capture Crayfishes. — Though they are found in the largest lakes and rivers as well as in the creeks and ponds, they are often near shore and in shallow water. One may wade in the shallow water of a stony creek, overturn stones, and seize them as

they attempt to escape. The collector knows that they dart backward, so he thrusts his hand down back of the crayfish to allow for the motion. In creeks running through or near towns frequently empty cans have been dumped into the water. These furnish good hiding places for the crayfishes and make their capture easy. Boys may thus readily capture enough to supply a class.

They may also be obtained by seining. In creeks and ponds when the water is low as in midsummer, or early fall, considerable numbers may be thus obtained. In creeks it is well to "work" carefully the holes about trees and stumps, and if the net cannot be drawn where they hide, the net may be held just outside and the crayfishes frightened out by thrusting a stick or pole in among the roots or under the ledges and other hiding places. A good minnow seine is desirable for this work. One may be improvised by using mosquito netting, but it is likely to tear easily and may lose the best specimens.

A dip net may be made similar to an insect net, but it should be stronger and heavier in every way. It is said that crayfishes are attracted to the bank by carrying a lantern along the streams at night.

Crayfishes may also be caught as crabs are caught, by tying a string to a chunk of meat or liver and letting it down into the water. The crayfishes often hold on till they are lifted out and dropped into a pail, but it is safer to have a landing net and slip it under them as the bait is lifted to the surface of the water; otherwise they often let go and are lost. Crayfishes may sometimes be caught by baiting with a worm in a crayfish hole. It is said that they may be induced to come out by making a slight noise at the mouth of the hole as though some animal were trying to enter. It is also stated that dropping a piece of lime into the hole will make the crayfish come out.

How to carry Crayfishes. — If one wishes to keep crayfishes alive, it is best not to try to carry many in a pail of water, but to put them in a box or basket with a good supply of wet leaves or paper, taking pains to keep them cool. They cannot endure much heat.

Crayfish in Aquariums. — It is best to keep only a few alive for any considerable length of time. These should be placed in a large aquarium with about two inches of water. It is well to have the aquarium inclined, so that they may crawl out of the water if they prefer. Place some bricks or stones in the water upon which they can crawl.

CRABS.

Collecting Crabs. — Crabs are often easily caught by baiting with meat. Tie a piece of meat to a string and let down off a wharf, or a convenient rock. Use a landing net when they are brought to the surface clinging to the bait. Otherwise you may lose a large share of them. Crabs may often be found in the tide pools at low tide. The fiddler crabs are often seen in great numbers on the southern coasts. The sand crab is a good runner. As you pursue him, be careful not to take your eye off him for an instant. He buries himself in the sand by one or two quick motions. As you approach, carefully keep your eyes on the spot where he disappeared and you may see the eyes, like two black beads, projecting from the sand.

Crabs may be obtained of fish and oyster dealers in nearly all the large cities, especially near the coast.

EARTHWORMS.

Collecting Earthworms. — These animals are so well known that there should be little difficulty in securing them, though often it is hard to get them large enough for dissection. They may be dug almost any time except in winter. The teacher is not likely to need them during the driest part of the summer, when they often go deep on account of drought, as they do on account of the cold of winter. It is well to get them some time before needed, as leaving any collecting to the last moment is likely to lead to disappointment. They should be kept in boxes of soil. For further suggestions as to keeping them, see the directions for field and laboratory study, given elsewhere. Specimens freshly killed by chloroform, or by weak alcohol, may be used for dissection. But

it is better to have them prepared beforehand, as follows. First rinse them in water till they are clean. Then kill them by putting them into fifty per cent alcohol, using plenty of the liquid for the number of specimens. They may also be killed by placing them in two or three times their bulk of water, and slowly adding an equal amount of strong alcohol. Let them remain in this about twelve hours. It is best to see that they are well straightened out; one good way to do this is to make a series of shallow troughs, of wood or paper, and lay each worm in one of these to keep it straight as it hardens. Then put them into seventy-five per cent alcohol for twenty-four hours. Last, transfer them to strong alcohol for preservation till needed.

FRESH-WATER CLAMS.

Collecting Clams. — Clams live in creeks and rivers, partially imbedded in the sand or mud as shown in Fig. 64. They may sometimes be found by tracing the furrow they have made as they plowed their way along the bottom of the stream.

Time for Collecting. — This should be done in warm weather, or at least before the water gets cold. Another advantage of collecting early is that the water is usually shallower early in the fall than later.

Method of Collecting. — If the water be warm, the collector can conveniently wear old clothes and a pair of shoes full of holes, so the water will run out of them. In colder weather thigh rubber boots are desirable. The thigh boots stay on much better than the hip boots. If the water be deep, the mackintosh wading pants are convenient, but they are more expensive. In shallow clear water the clams may sometimes be seen, though usually one has to find them by feeling. Often they may be first felt by the foot, but if the bottom be gravelly this is rather uncertain. The sleeve should at the outset be rolled to the shoulder. It will be seen that it will be very uncomfortable to do this sort of collecting in cold water, especially when the water is more than arm's length deep. As the clams are picked up, their position should be

noted. It is best to wash them as they are found, then throw them ashore to be gathered up later. They will not be injured by lying on the bank for an hour or so unless in very warm weather. They can be carried in baskets or tubs or in gunny sacs, as they will live a long time out of water if kept moist and cool. They will stand pretty rough handling, such as a ride in the bottom of a wagon box for a dozen miles, especially if cool water is poured over them occasionally. They should then be put into a tank or tubs in fresh water and kept in a cool place. By renewing the water they may be kept for a week or so in ordinary weather. A tank, with water supply and drain, built in the basement of the school building is a great convenience for keeping clams, crayfishes, frogs, or other aquatic animals.

Kinds of Clams to Collect. — In some localities the teacher may be thankful to find any kind, and may have to resort to the market and buy the salt-water clams that are sold for food. But in many places, especially in the Central states, there are plenty, and in variety; in some places the button-makers and the pearl hunters have almost exterminated them. For the study of the external features the clam known as the "sand clam" is one of the best. It is moderately convex, with distinct lines of growth, and is usually clean. It is therefore one of the easiest to draw. This kind is also easily opened. For dissection the black flat ones, with the high, sharp ridge below the umbo, is a good choice. It is easily opened, is flat, and, in consequence, lies nearly flat and does not need much water to cover it. It is especially good for the dissection of the nervous system on account of the marked orange color of the ganglions. Their color makes them easily seen, whereas in many other clams the ganglions are of about the same color as the surrounding tissues. The flat shells are also best for labeling the inside. For the study of the structure of the shell get the thickest shelled kinds. One especially thick and rough shelled species is common in the Central states. One of these thick-shelled species is more likely to have pearls, and is therefore, in some localities, rather thinned out. It will be well to

get two clams for each pupil and perhaps three. If two pupils dissect together, one may take the entire shell at the end of the first day's work, and the other the next day. It is better for each pupil to have a complete shell to see how the two valves fit together. One pupil may do all the dissecting the first day and the other the second. For economy of material the examination of the inside of the shell is placed after the dissection. If, however, the teacher has the cleaned shells all ready, this might be done immediately after the study of the external features.

Preservation in Alcohol or Formalin. — If the school has alcohol it will be well to preserve some of the clams in it. The dissection of the nervous system and of the digestive system is much easier in alcoholic than in fresh specimens. Where economy must be practiced, boiling will serve fairly well. One great advantage of the use of alcohol is that the material may be kept indefinitely and used when wanted, whereas it is difficult to get the fresh-water clams during the winter, or during the time of high water in fall and spring.

Preparation for Aquarium Study. — Get ready early so the water will have time to settle and become clear. Place some clams in natural position beforehand so the pupils can see them. This does not preclude the experiments of dropping the clams into the water to learn how the clams right themselves after losing their hold. If possible, have a live clam in sand in a jar for each two or four pupils, so it will not take so much time for them to learn about the locomotion, the opening and shutting of the shell, the siphons, and the water currents. If only one aquarium is used, the first pupils who experiment on the clam may make it close so no one can learn anything for some time. Encourage the pupils in having aquariums at home, where they will have more leisure to watch the life processes. Select clean sand for the aquariums. Sand that has been well washed will settle much sooner. Place some of the clams close to the side of the jar or aquarium so the foot can be seen. Be careful not to move the jar when watching the water currents, or the clam may close and suspend operations.

Also avoid jarring the table or floor. Do not introduce too much ink or mud when testing the currents, or the water will become turbid.

How to open Clams. — The method of opening by means of hot water is described in the directions to the student. It is of special advantage in using the thick-shelled clams that are very hard to open with a knife. The disadvantage of hot water is that it is likely to kill the clam, which is objectionable when the action of the heart or the muscles are to be studied. For opening clams use a medium-sized thin blade. An old, nearly worn-out pocket knife serves well, or an old table knife with the blade ground down to the size of a blade of a medium-sized pocket knife. A two-inch blade is long enough. It does better if rather dull, and is much safer if it should happen to slip. In the first place locate the adductor muscles by reference to cuts. Or, if there is plenty of material, learn by rough experience. The adductor muscles extend transversely from valve to valve near the anterior and posterior ends. These are to be cut close to the left valve. Hold the clam in the left hand with the left valve up, the anterior end away from you and the ventral edge against the palm. Hold the knife well back in the right hand, so that the forefinger is under the blade and the thumb resting on top of the blade, the edge being toward the back of the hand. Insert the blade near the posterior and dorsal margin back of the place where you think the posterior adductor muscle lies. Press the handle of the knife down, so as to keep the blade all the time very close to the left valve. Cut anteriorly and dorsally with a see-saw movement. After the point of the knife enters between the valves, the thumb should rest on the border of the valve to steady the knife. When the muscle has been severed, rotate the clam 180 degrees, taking care to keep the left valve up; the hinge should now rest against the palm, with the anterior end toward you. This time hold the edge of the blade toward you. Insert the blade at the anterior end and cut toward the umbo, following the precaution to depress the handle, otherwise you will not cut close to the shell, but will

mutilate parts that should be studied intact. Now the clam is ready for dissection, as directed for the student. The teacher will do well to practice on this until he can open clams without spoiling them. Pupils can be taught to do this, but it will be at the expense of time and specimens; for ordinary school work it will hardly repay. For those preparing to teach this should be carefully learned.

Supervision of Dissection. — 1. See that the student removes the *left valve*, and not the right. It is very desirable that the work be uniform. 2. Show the adductor muscles early in the work. Or, if it is found necessary to stop the work before reaching No. 20, whether on account of the limit of laboratory period or otherwise, have the pupils do what is directed in the first sentence of No. 20. If two pupils work together, as is often desirable, let one take the complete shell the first day. The next day let the other one do the dissecting and take the shell. 3. Do not let pupils waste time watching to see the foot or mantle draw up if those organs are already shortened to their full extent. 4. The teacher should show the ciliary action and the young clams or eggs, from the gills. 5. It is hard for the student to get a clear idea of the siphons, as the separation of the mantle lobes in the opened clam cause the siphons to disappear mysteriously. The teacher must resort to all the means devisable to make this clear. 6. Insist that during dissection the clam be kept under water. 7. Especial care must be taken not to injure the heart; the pericardium must be first cut along the dorsal border. 8. Have the janitor roast the shells. See to it beforehand that he has a large piece of sheet iron. This may be obtained from some scrap pile. After roasting, the less the shells are handled the better, as they are very easily crushed or broken.

Salt-water Clams. — While fresh-water clams are better, salt-water clams or oysters serve very well. These can be obtained in almost any town inland. If the teacher does not order direct from the nearest large city, he can order them at almost any meat market or fish market.

SNAILS.

Collecting Snails. — The European edible snails can be bought in some of the eastern markets. They are of good size and convenient for study. They may be kept alive in a cool, dry place. They become active when subjected to warmth and moisture, as when kept on damp sand. They may be killed by putting them into water that has been boiled to drive out the air and then cooled. Put the snails into such water in tightly capped jars. After twenty-four hours transfer them to five per cent formalin.

FISHES.

Buying Fishes. — For dissecting purposes suitable fishes can usually be obtained in the markets, if not in the small towns, certainly in the larger cities. In sending an order for such material it should be plainly stated that the fishes are wanted for study, otherwise they may be sent dressed as for the ordinary trade.

Collecting Fishes. — But pupils will learn almost nothing of the habits of fishes so long as only market fishes are studied. The teacher should take his class, or as many of them as possible, to the creeks or ponds, if any are accessible, and have as many of the students as can see the seine drawn, and watch the results of each haul. Of course most of the material thus hauled in will be thrown back, as it does not pay to try to take home a large amount. A number of "minnow pails" should be provided. There ought to be at least three pairs of rubber boots (unless this work is done in such warm weather that one can stay a long time in the water without any danger). Besides the two men hauling the seine a third should follow with the minnow pails. Into them whatever material is to be saved should be promptly placed. The selection should be quickly done so that the seine may be soon carried back over the water to dump the fishes that are not to be kept; if care is not taken to do this, many minnows and other fishes will be needlessly killed, and also the banks littered with decaying material. It is well to have one pair of wading pants,

and the man who wears these can go farther into the stream than one with ordinary wading boots. The "thigh" boots (*i.e.* those cut off squarely at the top) fit better and stay on more securely than the "hip" boots (which are oblique at the top and fit more loosely). Another advantage of the thigh boots is that, since they usually fit rather snugly around the thigh, if one steps into a hole and gets out quickly, he will probably not get much wet; whereas, with the wide, funnel-like top of the hip boots, a momentary dip will scoop up a lot of water which of course runs down to soak the whole leg and foot.

In seining care must be taken to "keep the lead line down" close to the bottom, otherwise many fishes will escape, especially when they find they are "cornered" as the seine approaches the bank. It is well also to have one or two extra boys beyond the ends of the seine, who by splashing may keep the fishes from escaping around the ends of the seine near the end of the haul. Many points besides these given may be learned by watching or asking the fishermen.

Carrying Minnows. — It is better not to try to keep many fishes in one minnow pail. If there are too many, it is likely that all will be found dead on reaching home; whereas half or a third as many might have been kept in good condition. They should be kept cool; if so kept it will not be necessary to change the water often. Care should be taken about changing the water, as they are likely to be killed by water of decidedly different temperature or quality. On reaching home it is best to pour them gently, with the water from their own stream, into a broad, shallow dish. If one has no aquarium, a dish pan serves very well.

Aquariums. — Various directions are to be found for making aquariums. Most home-made aquariums, however, soon begin to leak, and it is difficult to keep them in good order. It is cheapest, in the long run, to buy a good aquarium. They can be bought of the dealers, in sizes for ordinary school use, for from five to ten dollars. Such an aquarium will last indefinitely, but after a few years it may need new cement on the inside angles. In this, with

the fishes, should be placed some subaquatic plants in order to keep the water supplied with oxygen. If such plants are not readily found, they may be cheaply gotten from a greenhouse or from dealers in natural history supplies. Some pieces of irregular rock should be put into the aquarium and built into grottoes, for the fishes love hiding places. Also put in sand or gravel; in general, try to make the fish feel as much "at home" as possible. The more you succeed in doing this, the more natural will be their actions. For goldfish and minnows the prepared "fish food" is probably better than anything that you would be likely to give them. Be careful to give only a little at a time, or the water may become foul.

FROGS.

Collecting Frogs. — Frogs are best collected at night by going along the swampy shores or shallow water near shore in lakes, ponds, and creeks. The collector needs a good lantern and can usually pick up the frogs without any attempt on their part to escape. They may be kept in a box or cage in a damp place. They should have access to fresh water. A large shallow pan or trough will serve for this. A large tank in cellar or basement with water supply and drain is desirable for school buildings so that an abundant supply can be kept for late fall and winter use. They should be looked after daily and any dead specimens removed.

When capturing frogs in water they often escape by diving. Frequently they soon reappear, usually along the shore. Sometimes, however, they dive into the mud and there remain for some time. If a frog dives and fails to appear again, look for him in the mud, where his trail is indicated by muddy water or freshly disturbed mud.

Buying Frogs. — While it is best for the teacher, with some of his pupils, to collect the frogs, for the purpose of learning their habits, it is in most places more convenient to buy them. They are on sale for bait in the fishing-tackle department of the large houses dealing in sporting goods. Many such stores sell

them at twenty-five cents a dozen, which is cheaper than collecting them in person, as most teachers are situated. It is well to order them before cold weather sets in in the fall, as they cannot always be obtained. Still there are now a number of men who are in the business of supplying schools and medical colleges, so frogs can ordinarily be obtained at any season. But while larger frogs may be obtained of these dealers, they usually charge a higher price. It is very desirable that the teacher have a few of these larger frogs for preparing a sample skeleton and for general demonstration purposes. The teacher should early prepare a skeleton card and show the pupils how the work should be done, calling especial attention to any difficulties that they are likely to meet. If the teacher does not do this work himself, he will not know what these difficulties are, and he will not know how much time to allow for the task.

In preparing for the dissection of frogs by the class, put the required number into a jar, partly full of water; pour a small quantity of chloroform into the water and tightly cover the jar.

SNAKES.

Collecting Snakes. — In most places it is difficult to get enough snakes for individual work, even if this were desirable. This fact, together with the almost universal prejudice against snakes, throws the burden of this work upon the teacher. He will probably be obliged to do the dissecting and nearly all the work that involves the handling of snakes. But in most schools some of the boys will help in the collecting. They should be taught not to injure them during capture. First, of course, the collector should be sure the snake is not poisonous. A light blow, as with a buggy whip, generally simply stuns without serious injury. If one uses a stick, it may be pressed down on the snake till the foot can be placed on the neck, after which the collector can take hold of it by the neck. A holding stick may be made as follows: take a broom handle or rake handle; fasten a long strap at one end, as though to make a whip; put a loop (a wide staple) on the opposite side of

the same end; pass the strap back through the loop; leave a noose about three inches in diameter. This can be slipped over the head of the snake, and, by pulling, the snake can be held firmly and at comfortable distance from collectors who hesitate to take such specimens directly in hand. For carrying a live snake a strong bag is convenient; it should be securely tied, for snakes can push strongly and may escape from a loosely tied bag. An ordinary pail is not good, as a good-sized snake will push the cover off. The same is true of an ordinary tin can. A minnow pail with a hasp cover is secure, and has the advantage of giving a little air. While the snake does not need much air, it might be smothered in a fruit jar tightly capped. If one uses a fruit jar, the porcelain lining of the lid should be removed and a hole or two punched in the cover by driving a wire nail through it. For exhibiting snakes in the schoolroom a shallow box should be provided with a glass cover. It is well to have a screen window somewhere, but it does not pay to make a window of the screen, as one cannot see well through it and pupils will strain their eyes in the attempt. It is a good thing to have a good box made for this purpose, with hasp-and-staple fastening, and to keep this padlocked. The snake is less likely to escape, either by his own effort or through the desire of some one to play a practical joke. A box three or four inches deep will serve for all ordinary snakes. Several different kinds may be kept together, but if one wishes to feed them it may be well to separate them.

If in collecting you should be bitten by any of the non-venomous snakes, do not be alarmed. The writer has been bitten repeatedly, and has occasionally allowed a snake to bite the hand, but has never experienced the least inconvenience therefrom.

Dissection of a Snake. — For dissection get a large specimen; a live one is better, for the dead specimens are often mutilated. In a freshly killed snake the beating of the heart may be seen, and the persistent vitality of the nerves and muscles serve well to illustrate reflex action of the spinal cord. The snake may be killed by chloroform or by the following method: lay the snake's

head on a board, and with a knife cut entirely through the spinal column, just back of the head, or the spinal cord may be severed with forceps. Do not cut off the head. Take a piece of stiff wire as long as the snake (piano wire or spring brass wire) that is very straight; insert this through the opening at the back of the neck into the cranium, and stir it about to destroy the brain. This destroys all capability of sensation and of voluntary motion. Now run the wire down the cavity of the spinal column. In doing this it is necessary to have help. Let an assistant hold the tail end of the snake and straighten the body out in advance of the end of the wire. This destroys the spinal cord and prevents the reflex action of the muscles of the body, and makes it more easy to dissect. The wire should extend as far as the anus.

By preserving the skins of all the snakes collected enough may be accumulated to serve for tracing in Jordan's *Manual of the Vertebrates*. It is desirable that they be kept in dust-proof drawers or cases, and away from strong light, so they will not fade. The preservation of these skins is especially desirable where the institution does not have an ample supply of alcohol. And there is a decided advantage in the clean, dry specimens over alcoholic material for the average school student.

TURTLES.

Collecting Turtles. — Occasionally a turtle may be picked up; but since getting them in this way is uncertain, it is better, if several are wanted, to buy them of the fishermen. Sometimes they may be caught in seines in creeks. Young soft-shelled turtles are not infrequently captured in this way. Turtles should be kept in a moist, cool place. A large box or tank in a basement does very well. They will not need feeding during the winter.

How to kill Turtles. — They may be chloroformed by putting them in a tight box with a sponge holding chloroform. Still, this is a slow process, and the following method is recommended. Draw out the turtle's head, using pinchers if necessary. With a pipette or syringe inject a teaspoonful of chloroform into the

lungs through the glottis. The head may be chopped off; but it takes a turtle a long time to find out that he is dead, hence chloroforming is a better method.

BIRDS.

Kinds. — One of the best of birds for indoor or outdoor study is the English sparrow. It is abundant nearly everywhere, and can be readily obtained. Sparrows may be caught in a "figure four" trap, or by shutting them in at night after they have gone to roost in sheds and cupolas. They may also be shot. For this, use number nine shot. If one wishes to shoot them in a town, permission should be obtained from the proper authorities. In the country they are more likely to be found along hedges or near barns. In any case great care must be taken, and it will not do to trust small boys alone to do such shooting. The teacher will do well to enlist the aid of the boys of his class, but he would better go with them to aid and supervise. In the Central states crow-blackbirds usually gather in large flocks in the fall, preparatory to migrating southward. At this time they may be obtained in numbers sufficient for very large classes. It is desirable to have at least one for every member of the class to prepare a skin. In Illinois, for instance, it is legal to kill crow-blackbirds. At any rate, a teacher can procure a naturalist's license, permitting him to get birds for scientific purposes. But it ought not to be necessary to destroy many such valuable birds as robins, larks, etc. The crow-blackbirds, English sparrows, crows, jays, and a few others that are objectionable will supply most of what are needed in any considerable number. If possible each pupil might prepare a skin of a perching bird, a climber (woodpecker), wader (any snipe), bird of prey (hawk or owl), and a swimmer (duck). Any one who is preparing to teach will do well to have prepared several of these different types of birds. It is better to have some of them mounted with the wings outspread, or with some special arrangement of the parts to show the uses of the bill, feet, wings, or tail.

Collecting Birds. — For shooting blackbirds, if a large number is needed, several careful men should go to the roosting place about half an hour before sunset. Stationing themselves at various adjoining groves, they may get many birds as the flock passes from one grove to another. Number eight shot is about right for blackbirds. There should be several careful boys to pick up the birds as fast as they are shot. They should smooth out the feathers and lay the birds carefully in broad shallow baskets so they may not become soiled. A good way to kill a wounded bird is to pinch it strongly back of the wings. As soon as the birds are brought home, they should be carefully laid out in a cool place over night. They do best when laid on a shelf only one layer deep. The feathers should be smoothed again. They should be used, if possible, the next day. If kept on ice it will be found that they spoil very quickly after they are taken out in ordinary weather.

Carrying Birds. — In collecting in the fields and woods the most convenient way to carry birds is in a fish basket. Get the large-sized baskets. These baskets will hold a large number of birds and carry very comfortably. As soon as shot it is best to insert a wad of cotton into the mouth to prevent moisture from escaping and soiling the feathers. If there are conspicuous shot holes, these should be plugged also. Each bird should be kept in a paper cone. Newspaper serves very well for this. Take an ample supply when you go out collecting. Make a neat cone, bending over the tip so it will not unroll. Smooth the feathers and drop the bird in head first. See to it that the bill points to the tip of the cone and is not turned back. Now fold the open end of the cone neatly over the tail. Thus wrapped the birds will stand pretty close packing, but on a warm day it is well not to crowd them together too closely. In laying them away over night see that they are put where cats or other prowlers cannot get them. Teach each student how to make a cone and how to put a bird in it. If pupils are shown early in the term how to do this work, then all the birds that are brought to the class may be preserved. Any school may soon have a very good collection by

getting each pupil to contribute one bird. It is a good thing to have some large bird mounted with the wings outspread for illustrative purposes. For dissection, of course, birds that have been shot are not good. For this live pigeons are desirable. Kill them by chloroform in any tight box. Other birds can be used, but it is usually difficult to get them in sufficient numbers. Sparrows might be used, but they are rather small.

Collecting Eggs. — The collecting of birds' eggs by boys should be discouraged. They cannot, or usually do not, discriminate, and may do much harm. Such collections should be made under the supervision of experienced persons, who know enough to take no more than one egg, or at least but one at a time, from the nests of birds that lay only a few eggs. By doing this a collection may be formed without doing damage. The nest may be taken after it is abandoned, and with an egg selected here and there a full clutch may be shown, without having "robbed" a single nest, and without diminishing the number of young hatched. The rivalry of boys to get the most eggs, and the greatest number of kinds, leads to very bad results. Lead the boys to use the camera on adults, nest, eggs, and young. With care, much of this sort of work may be done without seriously disturbing the birds.

Preparation of Exhibition Bird Skins. — The teacher should prepare, or have prepared, one large bird as follows: After skinning and filling the body as directed in making a bird skin, instead of folding the wings, extend them to their full extent and mount the bird on a board long enough to include the whole spread. Instead of using a board wide enough to include the length of the bird, use a second board slightly longer than the bird, and nail this across the long board at right angles in the center. It will have the form of a cross. The long board should be wide enough to include the length of the secondaries. Such a preparation, especially of such a large bird as a turkey buzzard, or large hawk, will serve to show, to a good-sized class, the primaries, secondaries, and other features that the teacher may wish to demonstrate. Tack down the wings at various points. The head and bill may be

extended straight or turned to one side according to what is to be shown.

Collection of Birds' Feet and Wings. — Pupils should be encouraged to make collections of birds' feet to show the different uses, such as perching, swimming, wading, etc. These may be tacked to light, thin, smooth boards. A series of bills is also instructive. The teacher should also prepare a set of extended wings for class use in studying the effect of the arrangement of the feathers. Take wings of fresh birds and stretch them to nearly their full extent. Tack them in this position to boards; shingles serve very well, but it is better to use light dressed stuff, as they keep freer from dust and look better when the specimens are kept from year to year. After the wings have become dry, remove them from the board. They are now ready for use as directed in the study of the wing.

Elementary Classification of Birds. — For children, or beginners of any age, probably there is no more serviceable system of classification than the old one which groups them according to their place of living and mode of locomotion. According to this plan we have the Perching birds, as illustrated by the robin; the Climbing birds, as the woodpecker; the Waders, as the snipe; the Swimmers, as the duck; the Birds of Prey, as the hawk; the Fowls; and the Doves. We might first put them in three primary groups, the Water birds, the Land birds, and the Air (or Tree birds). Of course these classifications are not so exact as those of the ornithologists, but they are easier and in many respects more satisfactory with children.

MAMMALS.

Collecting Mammals. — Probably rabbits are the best mammals for class-room work. Children see them in the market and in the kitchen, and become accustomed to the idea of having them cut up; consequently they are not shocked as they might be at sight of the dissection of a cat. Rabbits may be caught in box traps, with the common "figure 4" door trip. Specimens in the market

have usually been killed by shooting and are not usually in good condition for dissecting, at least not for the dissection of the internal organs. If the nervous or muscular systems are to be studied, they serve very well. Ground squirrels may sometimes be obtained in sufficient numbers to supply a class. This is especially true in the central states, where the striped ground squirrel, or spermophile, is abundant in the fields. Boys often "drown them out," and save them alive. They should be kept in a very secure cage till they are to be killed, as they are likely to gnaw out of a wooden box. Enough for a large class may be killed at once by putting them in a tight box, or large jar and dropping in a small sponge holding a tablespoonful or two of chloroform. They may be dissected on a board as directed elsewhere. Rats can sometimes be obtained in numbers, caught in traps; but they are rather objectionable on account of their odor. If the teacher cannot get enough specimens for individual work by the students, he may get one for each four, or even larger group, in which case the students most inclined to this sort of work may do the dissecting and the others by watching may get a fair idea of the structure. Or, if but one or a few specimens are all that can be had, the teacher should do the dissecting and show the results to the class. In this sort of work it is better not to try to show too much at one time. Another specimen, later, may be used to show other features. The writer has found the following plan convenient in such demonstrations. Having the specimen on a table, the teacher takes his place at one end, and has the students pass on each side, and the structures to be exhibited are explained to a group of from six to ten, according to the nature of the points to be shown, the light, size of the class, time of the laboratory period, etc. To save time and avoid confusion have a regular order of passing to and from the demonstration table.

Injection of the Arteries. — The arteries and veins, unless distended with blood, are so nearly of the same color as the surrounding tissues that it is difficult to distinguish them. Hence it is very desirable to fill them with some colored substance.

The following starch preparation, recommended by Wilder and Gage in their admirable work, *Anatomical Technology*, has been found very satisfactory : —

STARCH INJECTION MASS.

Dry starch (" Laundry " is good)	100 c. c.
Water, or a 2½ per cent aqueous solution of chloral hydrate	100 c. c.
Alcohol (95 per cent)	25 c. c.
Color mixture (as given below)	25 c. c.

" After thoroughly mixing the mass, it should be filtered through one or two thicknesses of moistened paper cambric. To prevent the starch from settling, the cloth should be tilted from side to side, or the mass may be stirred during the filtration. If the mass is not freshly prepared for every injection, the stock mass should be filtered occasionally, to remove hair or any other object that might clog the cannula.

" Since almost any animal injected may afford some organ worth preserving, it seems better to employ permanent colors in tingeing the mass. Among these which are available, the following, probably, are preferable : vermilion, red lead, ultramarine, Berlin blue, chrome orange, yellow, or green.

PREPARATION OF THE COLOR.

Dry color	100 c. c.
Glycerine	100 c. c.
Alcohol (95 per cent)	100 c. c.

" To avoid lumps, which would clog the cannula or small blood tubes, the color should be thoroughly ground in a mortar. It should be stored in a well-stoppered bottle, and is prepared for use by simply shaking. If permanent preparations are not to be made, the mass may be stained by aniline of the desired color."

Excellent results have been obtained by the use of carmine in coloring the mass for injecting the arteries, and Berlin blue or Prussian blue for the veins.

Kill a cat or rabbit with ether or chloroform, by putting the animal into a tight box or jar with a sponge containing a tea-

spoonful of the anesthetic. When the animal is dead, open the thorax by cutting across the posterior ends of the breastbone, and through the costal cartilages on each side, being careful not to cut the mammary artery which runs along the inside of the breastbone on each side. The mammary artery should be tied just under the anterior end of the breastbone. Now cut away the breastbone. The breastbone may be simply turned forward, and in this case it will not be necessary to tie the arteries.

Find the aorta, and clear away any tissues that may obscure its base. Pass a ligature under the aorta here, but do not tie until the cannula is inserted. Cut a small slit in the apex of the left ventricle. Have in readiness several cannulas (or nozzles of a brass syringe) of different sizes, made by drawing out glass tubing. Each cannula should have a distinct neck, so that it may be tied in firmly. Insert the cannula through the ventricle into the base of the aorta. Now tie the cannula firmly by the surgeon's knot, made by crossing the two ends of the thread twice instead of once, as in the ordinary knot; draw firm with a slight sawing motion, but do not tie again. (See Fig. 1.)

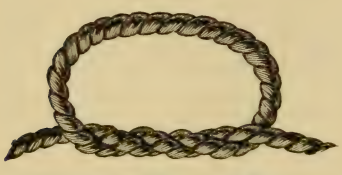


FIG. 1. — Surgeon's Knot.

For injecting, use a good brass syringe, if it can be had; a white-metal syringe serves fairly well.

Demonstration of the Action of the Heart. — Get the heart and lungs entire. Dissect out the aorta as before. Clear the pulmonary artery, and cut off both branches close to the lungs. Carefully trim away the pericardium, and clean the precaval and postcaval veins. Turn the heart back, and find one of the larger pulmonary veins; cut a hole in it near the lung, and slip a glass tube into it toward the heart. This tube should have a groove, made by drawing it out in the flame. Another, and perhaps easier, way to keep the glass tube from slipping out, is to slip over the end of the tube a piece of rubber tube an inch or two long; but it should not project beyond the end of the glass tube. If

this fits snugly, it will not slip on the glass tube, and the blood tubes will hold firmly when tied over the rubber. It is much better to tie the tube into the pulmonary vein before the vein is cut off; otherwise there will be difficulty on account of the shortness of the pulmonary vein. Tie the tube firmly in, and ligature the other pulmonary veins without stopping to trace them. Tie all connections with the heart now remaining, and cut beyond the ligatures. Get a retort stand and two large glass funnels, or have made a more convenient piece of apparatus (as shown in Fig. 19 of the author's *Physiology, Experimental and Descriptive*), consisting of a sheet-iron pan eighteen inches square and two inches deep, with a fixed bail handle twenty inches high, made of iron rod of the size of a retort stand rod. Attach retort rings and clamps to the rod, as shown in the figure. This whole apparatus, with the heart attached according to the directions given, can easily be carried, and any overflow of liquids will be caught by the pan. Place the funnels in the rings. Lay the heart, now wholly severed from the lungs, on its ventral surface. Connect one funnel, by rubber and glass tubing, with the left auricle by the tube already in the pulmonary vein; connect the other funnel with the right auricle, through the precaval vein; ligature the postcaval vein. Lay the heart in a basin, and pour water into the funnels; hold the heart with the two hands, and compress it, repeatedly adding water. In this way the clotted blood usually present in the right ventricle may be washed out. If this remain, it may interfere with later experiment. Connect the aorta with the funnel which leads to the right auricle by means of a glass tube which bends over the edge of the funnel, thus holding itself in place by the hook, or held above by a clamp or ring, and emptying into this funnel any liquid which escapes from the tube. In like manner have a bent glass tube, from the pulmonary artery, held by a clamp above the funnel leading to the left auricle.

Let the heart soak in water, inside and out, over night before showing it to the class. This will loosen the clots, and make the valves more flexible.

Pour water into one of the funnels, and compress the heart to imitate its natural contraction; observe where the liquid next appears; add more water, and follow it around to its starting point. A little ink may be poured into one of the funnels, and traced around, as the heart is worked, to its starting point.

That there is no direct connection between the two halves of the heart may be shown by letting the liquid from each artery empty into the funnel connected with the auricle of the same side of the heart. Different-colored liquids may be used in the two funnels.

In order to illustrate more fully how the heart is composed of two pumps fastened together, and each pumping its own stream, but worked by the same power, try the following: —

Take the two funnels supported as in the preceding experiment; connect each funnel with the supply tube of a common bulb syringe; connect the delivery tubes with the bent tubes used with the heart.

1. Let each bent tube empty into the funnel from which it gets its supply. There are now two distinct circuits.

2. Now cross the delivery tubes so that each discharges into the funnel from which the other gets its supply. Now, on working the bulbs, we have a circuit like a figure 8, really one circuit, but the two streams cross each other.

3. Again, place the two bulbs side by side, and work the two with one hand.

4. Wrap a cloth around the two bulbs, so that what is contained in the cloth cannot be seen. We have now a structure like the heart. We know that it consists of two pumps wrapped together and working together; that is, by the same stroke, but with two wholly independent currents.

PROTOZOA.

Collecting Protozoa. — Amœbæ are likely to be found in the ooze at the bottom of ponds or still waters. Scrape up some of the ooze, being careful to get little, if any, of the underlying mud. Gather leaves and grasses that have fallen into the water. If these

have a slimy coating they are likely to supply you with a variety of protozoans. Get a number of jars of such material, half full of water. Keep the material from different sources separate. The contents of the jars or bottles may be emptied into small open jars, and kept in the laboratory. They should not be placed in direct sunlight. Protozoans may often be found in vases where plants have been kept, and often develop in water in which hay or apple peelings have been placed. Cut off little pieces of living aquatic plants and mount in water. Many of the protozoans, as well as larger animals, like the shelter afforded by plants.

SPONGES.

Collecting Sponges. — The study of sponges is so difficult that it is not likely to be profitable for most classes. Still, if sponges occur in your vicinity, you ought to find them and at least show them as entire objects. Look for fresh-water sponges in lakes, ponds, and quiet water in streams. They vary in color from green to yellowish or brownish. Of course you will look for an attached mass, of rather diffuse form, but having a general "spongy" appearance. If the sponge is attached to rock, carefully scrape it off; if fastened to wood, chip away enough of the wood to get the specimen entire. It may be kept in water for a short time, but is best preserved in alcohol. The marine sponges that the ordinary collector is likely to find are usually light-colored; some are compact, but many are tubular or often composed of branching tubes.

CŒLENTERATA.

Collecting Hydras. — Hydras are widely distributed in fresh water, and can be found in most places in the United States. It is not easy to see them in the water in lakes, ponds, and quiet waters, where they may abound. They are usually attached to the under surfaces of leaves, or to stems where they are not readily seen from above. Then, too, almost any way of getting at

them will disturb the water so much that the hydras will probably be contracted when the observer gets close enough to see them. The best way is to gather a quantity of fresh water-plants, especially plants that grow mostly submerged. This material, with a good supply of the water from which it is taken, should be carried home and kept in small jars. The advantage of small jars is that you can more easily see through them. Set these jars away, out of the sunshine. After a time the hydras will expand again. Look through the jar toward a good light. Look for a slender, threadlike body about a half an inch long, with a circle of radiating arms at the free end. These arms may be half an inch in length. Hydras may be colorless, or white in appearance, or they may be light brown or even green. There are said to be three species, distinguished by these colors. In the central states the colorless form is the common one, and you should look for a whitish-appearing object. When you find one, watch it to see if it moves; if it progresses; if it eats; if it grows; if it produces other hydras, etc. When you wish to examine one under the microscope, cut off a bit of the leaf or stem to which it is attached. If it is attached to the inside of the jar, carefully scrape it off, suck it up with a medicine dropper, and transfer to a slide or to a watch-glass in a little water and examine, first under a low power of the microscope, later with a higher power.

Collecting Hydroids. — Those on the seashore can usually find an abundance of hydroids, the best time for this, as for almost all marine collection, being at low tide. On seaweeds, on the piles under wharves, on rocks and timbers, are to be found a variety of the hydroids; to the beginner it may be best to say "look for mosslike growths." These may be pale, almost white, dull brown, greenish, or pink. They should be kept in salt-water aquariums, and may be preserved in alcohol for later study. It is difficult to preserve them in an expanded state, and the collector should learn how to do this at some of the marine laboratories, such as Woods Hole, Mass., or Cold Spring Harbor, L. I.

The smaller jellyfishes, known as medusas, are obtained by the

hand net or tow net. The best time for this collecting is at sunset and during the early evening when the sea is calm, for then the medusas swim at the surface. The net, after towing awhile, should be taken up and turned inside out and rinsed in a pail of sea-water. This water may then be poured into a number of small glass jars; large beakers serve very well as they are thin, clear, and light in weight. Hold the jar up toward the light. When a form is found that you wish to examine under the microscope, dip it up by means of a glass tube thus: place the tip of a finger over one end of the tube, and lower the other end to a point just above the specimen. Now lift the finger till the water is sucked up into the tube; replace the finger on the end of the tube, lift the specimen out, and transfer to slide or watch glass. Most of these forms will be dead before morning if left in a pail of sea water. In handling the larger jellyfishes avoid contact with the back of the hand or any delicate portion of the skin, or you may learn too well why they are often called "sea nettles."

Sea anemones may be scraped from their attachment. Coral polyps should also be collected, with the hard secretion, or coral, made by the polyps. To preserve any of these forms in an expanded condition is very difficult for a beginner, and the teacher should learn this under supervision at one of the several excellent marine laboratories, elsewhere mentioned. Such material, in condition for study, may be obtained from these laboratories, or collectors usually connected with them, of which a list is given on p. 52.

ECHINODERMS.

Collecting Echinoderms. — The echinoderms are well suited for practical work, especially for students living near the coast. Starfishes and sea urchins may be preserved in alcohol, putting them first in fifty per cent alcohol, and later in seventy-five per cent or stronger. It is well to cut a slit in one ray of each starfish so the alcohol may penetrate; otherwise these and many other forms with tough skins may actually spoil inside before the alcohol reaches them. Then when dissection is attempted the internal organs are

in such bad condition that no good results can be obtained. Puncture the oral membrane of the sea urchins before placing in alcohol. Take the same precaution with sea cucumbers.

In preparing dried starfishes, first kill them by placing them in fresh water (or "sweet water" as the sailor would say). They may then be dried in hot sunshine. It is rather safer to kill them in alcohol, and then dry them in the sun. Each student should have an alcoholic and a dried specimen. It is a good plan, especially where dissection is not undertaken, to give each student a dried specimen to keep; also if possible a test of a sea urchin and a cake urchin, sand star, etc. These he should keep in his individual collection. If he becomes a teacher, he will make good use of these specimens. Even if he does not, they will be a source of interest and instruction, not only to him, but to the members of his family where he is sure to exhibit them. The echinoderms are exclusively marine, and to people who have never visited the coast, any such specimen is suggestive of the "wonders of the deep." The school ought to do something toward educating the community through the students. But in most cases, it will be better for the inland teacher to pass over these forms rather lightly, since he is not likely to have an abundance of material, without considerable expense. Each teacher should dwell most on the forms in the immediate vicinity. Thus, while he may exhibit a few specimens that come from a distance, and at least teach the students to recognize their external form, the home fauna should receive the most attention.

FLATWORMS.

Platyhelminthes or Flatworms. — The writer does not recommend that beginning classes attempt the practical study of this group. Planarian worms may be found under sticks and stones in many ponds. Specimens of the tapeworm can usually be obtained from the nearest physician. But in the limited time at the disposal of most classes it will undoubtedly be better to put the time on other forms.

ROUND WORMS.

The Nemathelminthes, or Round Worms. — These, too, are rather beyond the ordinary student, so far as practical work is concerned. Specimens of parasitic round worms, including pin worms and Trichinæ, can be obtained of physicians or of dealers in microscopic mounts.

ROTIFERS.

The Trochelminthes, or Rotifers. — The rotifers, or wheel animalcules, are found in the same situations as many of the protozoans, and they may be collected, kept, and examined in about the same way.

MOLLUSCOIDA AND POLYZOA.

The Molluscoida. — The brachiopods, or lamp shells, have the appearance of bivalve mollusks; hence the name of the group. They are obtained by dredging off the coast, and are not adapted to practical work by elementary students. Of the Polyzoa, many marine forms resemble the hydroids, but examination shows that the Polyzoa are much more highly developed than hydroids, having a distinct digestive tube. From their tufted appearance they have been called Bryozoa, or moss-like animals. There are several kinds of fresh-water polyzoans. One form, not uncommon in the lakes and streams of the Central States, consists of a spherical gelatinous mass attached to submerged stumps or branches. The clusters of minute animals are on the surface. The mass is sometimes as large as a child's head; the fishermen call them sponges. When they become waterworn, there remains a mass of clear, tough, jelly-like substance that has puzzled many a naturalist. Occasionally the mass forms around green plant growths, such as Algæ, thus making more difficult the solution of the mystery. This form is *Pectinatella magnifica*.

LIST OF REFERENCE BOOKS FOR STUDENTS.

GENERAL.

Riverside Natural History (6 vols.), Kingsley; Houghton, Mifflin, & Co.

Cambridge Natural History (incomplete), Harmer & Shipley; The Macmillan Co.

Commercial Products of the Sea, Simmonds.

Manual of the Vertebrates, Jordan; A. C. McClurg & Co.

The Crayfish, Huxley; D. Appleton & Co.

The Formation of Vegetable Mould through the Action of Earthworms, Darwin; Appleton.

BIOLOGIES.

General Biology, Sedgwick and Wilson; Henry Holt & Co.

Animal Biology, Morgan; Longmans, Green, & Co.

Elementary Biology, Parker; Macmillan.

SCHOOL ZOÖLOGIES.

Packard (Holt); Thomson (Appleton); Parker and Haswell's Manual (Macmillan); Kingsley (Holt); Jordan and Heath (Appleton); Needham (American Book Co.); Davenport (Macmillan); Harvey (American Book Co.); Kellogg (Holt); French (Longmans); Morse (American Book Co.); Dodge's General Zoölogy (American Book Co.); Holder (Appleton); Burnet (American Book Co.); Merrill's Studies in Zoölogy (American Book Co.).

INSECTS.

A Manual for the Study of Insects, Comstock; Comstock Pub. Co., Ithaca, N. Y. A Guide to the Study of Insects, Packard; Holt. The Insect Book, Howard; Nature Biographies, Weed; Doubleday, Page & Co. Romance of the Insect World, Badenoch; Macmillan. Elementary Studies in Insect Life, Hunter; Crane & Co. The Transformations of Insects, Duncan. The Structure and Habits of Spiders, Emerton; S. E. Cassino. Butterflies of the Eastern United States, French; J. B.

Lippincott Co. The Butterfly Book, Holland. On the Origin and Metamorphosis of Insects, Lubbock; Appleton. Ants, Bees, and Wasps, Lubbock; Appleton. The Life of a Butterfly, Scudder; Holt. Butterflies — Structure, Changes, and Life-histories, Scudder; Holt. Injurious Insects and Insecticides, Semper. Life-histories of American Insects, Weed. Insect Life, Comstock; Appleton. Entomology for Beginners, Packard; Holt. Half-hours with Insects, Packard; Lauriat. Economic Entomology, Smith; Lippincott. American Spiders and their Spinning Work, McCook; Acad. Nat. Sci., Phila. Moths and Butterflies, Dickerson; Ginn & Co. Moths and Butterflies, Ballard; Putnam. Frail Children of the Air, Scudder; Houghton, Mifflin, & Co.

BIRDS.

Key to the Birds of North America, Coues; Estes. A Manual of North American Birds, Ridgway; Lippincott. Land Birds; Water Birds, Cory; Field Columbian Museum. Birds of the United States, Apgar. Handbook of Birds of Eastern N. A., Chapman; Putnam. Among the Waterfowl, Job; Doubleday, Page, & Co. Bird Life, Chapman; Appleton. How to Name the Birds, Parkhurst; Scribner. Citizen Bird, Wright; Macmillan. Birdland Echoes, Abbott. Birds, Bees, and Sharp Eyes, Burroughs. Curiosities of Bird Life, Dixon. Bird Neighbors; How to Attract the Birds; Birds that Hunt and are Hunted, Blanchan; Doubleday, Page, & Co. Birds of Field and Village, Merriam. Bird Ways; In Nesting Time; Upon the Tree Tops; Little Brothers of the Air; A Bird-lover in the West, Miller; Houghton, Mifflin, & Co. The Birds' Calendar, Parkhurst; Scribner. Bird-craft, Wright; Macmillan. Story of the Birds, Baskett; Appleton. Home Life of Wild Birds (photographs), Herrick; Putnams. Every Bird, Howe. Bird-dom, Keyser; D. Lothrop & Co. News from the Birds, Keyser; Appleton. In Bird Land, Keyser; A. C. McClurg & Co. Some Common Birds, Silloway; The Editor Pub. Co., Cincinnati. Birds in the Bush, Torrey; Houghton, Mifflin, & Co. Our Own Birds, Baily; Lippincott. The English Sparrow, Barrows; The Common Crow, Barrows and Schwarz; The Hawks and Owls of the United States, Fisher; the last three are published by the United States Department of Agriculture.

MAMMALS.

Squirrels and other Fur-bearers, Burroughs. Four-footed Americans, Wright. Wild Beasts, Porter. Mammals, Living and Extinct, Flower and Lydekker; A. & C. Black.

SMITHSONIAN PAMPHLETS.

The following pamphlets of the Smithsonian Institution are printed by the government, as parts of the Bulletin of the United States National Museum: —

Directions for Collecting and Preserving Insects, Riley; Instructions for Collecting Mollusks, and Other Useful Hints for the Conchologist, Dall; Directions for Collecting Reptiles and Batrachians, Stejneger; Directions for Collecting Birds, Ridgway; Directions for Collecting, Preparing, and Preserving Birds' Eggs and Nests, Bendire; Directions for Preparing Study Specimens of Small Mammals, Miller; Notes on the Preparation of Rough Skeletons, Lucas. The Oyster Industry, Ingersoll; Government Printing Office, Tenth Census of the United States.

BOOKS ON GENERAL OUTDOOR OBSERVATION.

A Naturalist's Rambles about Home, Abbott; Appleton.

Each student should read at least part of this book in order to see how much can be learned by observation around his home.

Seaside Studies in Natural History, Agassiz. Wake-Robin, Burroughs; Houghton, Mifflin, & Co. Locusts and Wild Honey, Burroughs. Animals' Ways and Claims, Carrington. Ways of Wood Folk, Long. Animals at Work and Play, Cornish. Wild Animals I have known, Seton. Outdoor Studies, Needham. Zoölogical Sketches, Oswald. Life on the Seashore, Emerton. In Brook and Bayou, Bayliss; Appleton. Life and Her Children, Buckley; Appleton. The Foot-Path Way, Torrey. Curious Homes and Their Tenants, Beard; Appleton. Eye Spy, Gibson. Walden, Thoreau.

ECOLOGY, DISTRIBUTION, AND DEVELOPMENT.

Animal Life, Jordan and Kellogg; Appleton's.

There ought to be several copies of this book in the library and each student should read at least part of it.

Animal Life and Intelligence, Morgan; Ginn & Co. Habit and Instinct, Morgan. On the Senses, Instinct, and Intelligence of Animals, with special reference to Insects, Lubbock; Appleton. The colors of Animals, Poulton; Appleton. Animal Life, as affected by the Natural Conditions of Existence, Semper; Appleton. Animal Mechanism,

Marey ; Appleton. Geographical Distribution of Animals, Wallace; Harper. Zoögeography, Beddard. The Development Theory, Bergen. The Origin of Species, Darwin. The Variation of Plants and Animals under Domestication, Darwin. The Study of Animal Life, Thompson. The Play of Animals, Groos. Distribution of Animals, Heilprin. Comparative Physiology and Morphology of Animals, Le Conte ; Appleton.

GENERAL NATURAL HISTORY, EXPLORATION, AND HUNTING.

Voyage of the *Beagle*, Darwin; Campfires of a Naturalist, Edwards; Appleton. Around the Campfire, Roberts. Wild Life at Home; how to study and photograph it, Kearton. The Wilderness Hunter, Roosevelt; Putnam. Hunting Trips of a Ranchman, Roosevelt; Putnam. Books of the Boone and Crockett Club (3 vols.), Roosevelt and Grinnell; Forest and Stream Pub. Co. Wild Beasts and Their Ways, Baker. The Big Game of North America, Shields. Book of the Black Bass, Henshall; Food and Game Fishes, Jordan and Evermann; Doubleday, Page, & Co. The Deer Family, Roosevelt; Macmillan. The Still Hunter, Van Dyke. American Animals, Stone and Cram. Nature and the Camera, Dugmore. American Duck Shooting, Grinnell; Forest and Stream Pub. Co.

BOOKS FOR THE TEACHER.

Text-book of Zoölogy (2 vols.), Parker & Haswell; Macmillan. Handbook of Invertebrate Zoölogy, Brooks ; Bradlee Whidden. Practical Zoölogy, Marshall and Hurst ; Smith, Elder, & Co. Practical Biology, Dodge ; Harper. Anatomical Technology, Wilder and Gage; A. S. Barnes. The Cat, Reighard and Jennings. Zoötomy, Parker ; Macmillan. Practical Biology, Huxley and Martin ; Macmillan. Atlas of Biology, Howes ; Macmillan. Guides for Science Teaching, Hyatt ; D. C. Heath & Co. Taxidermy and Zoölogical Collecting, Hornaday. Nature Study and Life, Hodge. (Every teacher should read this book.) Nature Study and the Child, Scott. Nature Study, Jackman ; Holt. Nature Study in Elementary Schools, Wilson ; Macmillan. Mental Evolution in Animals, Romanes ; Appleton. Animal Intelligence, Romanes ; Appleton. Teacher's Manual of Bird Life, Chapman. Manipulation of the Microscope, Bausch ; Bausch & Lomb Optical Co., Rochester, N. Y. Insecta, Hyatt ; D. C. Heath & Co. Studies of Animal Life, Walter, Whitney, and Lucas ; D. C. Heath & Co. Invertebrate Zoölogy, Pratt ; Ginn & Co. Invertebrate Zoölogy, Bumpus ; Holt. A Text-book of Zoölogy, Mudge ; Longmans.

MAGAZINES.

Science ; American Naturalist ; Forest and Stream ; Recreation ; Popular Science Monthly ; Outing ; School Science ; American Monthly Microscopical Journal ; Journal of Applied Microscopy, Bausch & Lomb Optical Co., Rochester, N.Y.

DEALERS IN ZOÖLOGICAL SPECIMENS.

A. A. Sphung, North Judson, Ind. (frogs, crayfishes, clams, etc.). B. F. McCurdy, 313 East 65th Place, Chicago (frogs, crayfishes, etc.). A. Booth & Co., 2 La Salle Ave., Chicago (salt-water clams, oysters, lobsters, and fish of all kinds). C. E. Blake, 1486 East 69th St., Chicago. G. K. Cherrie, Brooklyn Institute Museum, East Parkway and Washington Avenue, Brooklyn, N.Y. (marine material). C. J. Maynard, 447 Crafts St., West Newton, Mass. F. G. Hillman, New Bedford, Mass. Aquarium Supply Co., Delair, N.J. F. W. Wamsley, Academy Natural Science, Philadelphia. Marine Biological Laboratory, Wood's Holl, Mass. H. H. & C. S. Brimley, Raleigh, N.C. Ludwig Kumlein, Milton, Wis., taxidermist (birds and mammals). Frye and Ruthven, Morningside College, Sioux City, Ia. W. C. Kaempfer, taxidermist, 88 State St., Chicago. "The Fair," Chicago (frogs).

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Bausch & Lomb Optical Co., Rochester, N.Y. Eimer & Amend, New York. James W. Queen & Co., Philadelphia. Williams, Brown, & Earle, Philadelphia. The Franklin Educational Company, Boston, Mass. Spencer Lens Company, Buffalo, N.Y. William Krafft, New York.

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Bausch & Lomb Optical Co., Rochester, N.Y. Sharp & Smith, Chicago.

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Bausch & Lomb Optical Co., Rochester, N.Y. Queen & Co., Philadelphia. John Akhurst, Brooklyn, N.Y. M. Abbott Frazar, Boston, Mass. Entomological Society of Ontario, London, Ont. Charles C. Reedy, San Francisco, Cal.

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